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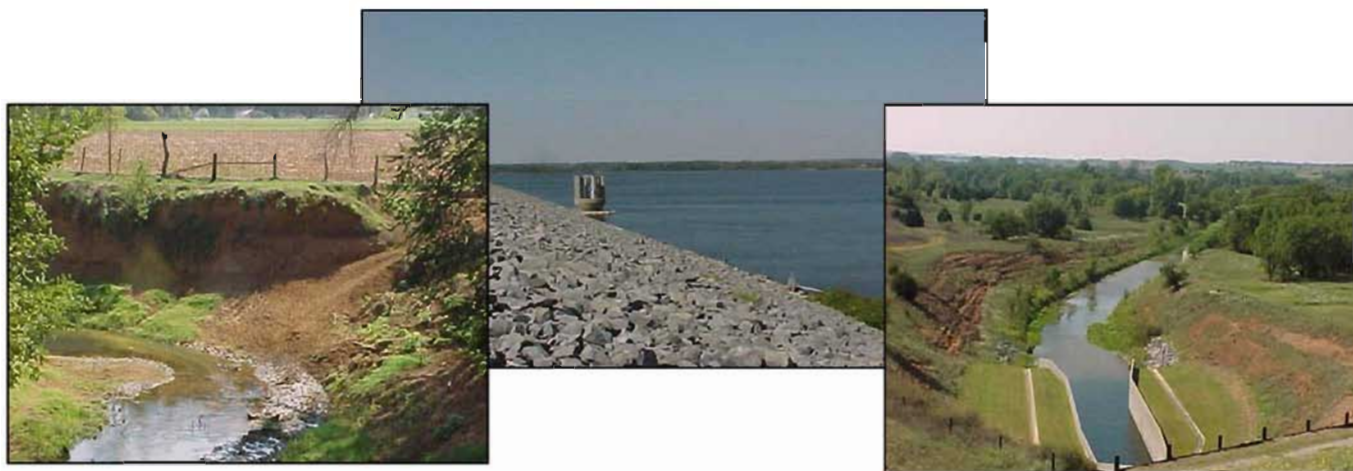
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Columbia Environmental Research Center



An Integrated Assessment of the Trophic Status of Fort Cobb Reservoir, Oklahoma

Final Report To

Jeff Lucero
Great Plains Region
U.S. Bureau of Reclamation
Billings, MT

By

James Fairchild, Ben Lakish, Kathy Echols, Duane Chapman, Thomas Johnson, and Susan Jones

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EXECUTIVE SUMMARY

A study was conducted to determine the sources, fate, and effects of nutrients and bacteria in Fort Cobb Reservoir, OK. A total of 26 sampling sites were studied on a bimonthly basis from June 2000 to June 2002. Results indicated that Fort Cobb Reservoir is highly eutrophic based on Carlson Trophic State Indices (TSI) of total phosphorus (TSI = 67), algal biomass (TSI = 61), and water clarity (TSI 67). This trophic classification indicates that the reservoir contains excessive concentrations of nutrients that are resulting in high concentrations of algal biomass; furthermore, water clarity of the reservoir is low. Collectively, these observations indicate that water quality is reduced, with emerging problems associated with taste, odor, and recreational values. Concern over these water quality conditions were frequently expressed by recreational users during the course of the study.

The reservoir is well mixed, but shows some signs of late summer stratification based on dissolved oxygen and pH depth profiles; however, there is no evidence of a thermocline. Dissolved oxygen and pH stratification occurs during periods of maximum temperature and low mixing. Lack of mixing, paired with light limitation, leads to a decrease in primary productivity and resultant oxygen depletion and CO₂ increase due to respiratory demands at greater depths. Continued water quality degradation could ultimately lead to greater dissolved oxygen depletions and impacts on fish and wildlife.

Water quality is poorest in the upper end of the reservoir near the tributary inflows but improves somewhat towards the dam. Highest algal biomass occurs in the upper reservoir and embayments. The lake is dominated by cyanobacteria (blue-green algae), which comprise over 90% of the phytoplankton numbers. Primary algal genera in order of occurrence include *Microsystis*, *Wollea*, *Anabaena*, *Oscilliatoria*, *Merismopedia*, *Anabaenopsis*, and *Aphanizomenon spp.* The algal toxin microcystin is highest during mid to late summer and reaches approximately 15% of the World Health Organization's concentration of concern of 1 µg/L.

The Cobb Creek, Lake Creek, and Willow Creek sub-watersheds comprise 62%, 26%, and 11% of total acreage of the Fort Cobb Watershed, respectively. All tributaries contribute elevated nutrients and bacteria to the reservoir. However, Cobb Creek contributes proportionally

more discharge (and hence total nutrient loading) to the reservoir compared to Lake Creek or Willow Creek.

Total coliform and *Escherichia coli* bacteria are elevated in all tributaries. *E. coli* concentrations are highest in the tributaries and upper end of the reservoir after periods of high runoff in early spring. In general, *E. coli* numbers are rapidly attenuated down-reservoir towards the dam. One exception to this, however, is the December to February period when overwintering populations of waterfowl contribute high concentrations of *E. coli* and ammonia to the mid-lake and near-dam areas.

Currently, there is a 319 Demonstration Project in the Lake Creek Watershed that is implementing educational programs and land-use changes to improve water quality in the reservoir. However, it is unclear how successful this will be in reversing water quality declines for two reasons: 1) Lake Creek comprises only 26% of the total watershed, and 2) there is a large internal load of sediment-associated nutrients that are available to the water column via wind action, wave action, and bioturbation. Quarterly monitoring of a suite of water quality variables (depth-integrated measures of chlorophyll *a*, total nitrogen, total phosphorus, Secchi depth, and *E. coli*; and depth profiles of temperature, dissolved oxygen, pH, and turbidity) at a minimum of three sites (Sites 0, 3, and 6) is recommended to monitor the trajectory of water quality conditions in Fort Cobb Reservoir and to determine the success of management efforts to reduce non-point source pollution inputs and impacts.

INTRODUCTION

Fort Cobb Reservoir is a 4,100 acre reservoir located in a 314 square mile watershed in Caddo County, southwestern Oklahoma (Oklahoma Water Resources Board 1990) (Figure 1). The reservoir is managed by the U.S. Bureau of Reclamation (USBOR) for drinking water supplies, irrigation sources, flood control, recreation, and fish and wildlife habitat.

Fort Cobb Reservoir lies within a watershed dominated by sandy loam soils. Land use in the watershed is approximately 87% cropland, 9% rangeland, 2% water, 2% forest, and 1% urban (Table 1; Figure 2; Paul Yue, OKDEQ, personal communication). Therefore, agriculture is the primary land use. Primary row crops include peanuts, wheat, and cotton. Livestock operations are dominated by pasture grazing of cattle and several large confined animal feeding

operations (CAFOs) used for hog production. Martin (2002) cited U.S. Department of Agriculture statistics and indicated that Caddo County contains approximately 130,000 head of cattle and 12,000 hogs; however, these were county-based statistics that do not necessarily relate directly to numbers of livestock in the Fort Cobb Watershed.

Fort Cobb Reservoir has been listed by the State of Oklahoma as impaired based on the 305(b) Report to Congress (OKDEQ 2000). The reservoir has been listed as impaired due to excessive inputs of nutrients, sedimentation, and pesticides from row cropping and livestock production. Confined animal feeding operations are of particular concern, because they produce huge amounts of animal waste products containing significant amounts of nitrogen and phosphorus. These confinement facilities have little capacity for primary or secondary waste treatment and primarily store wastes in on-site retention lagoons. Excess waste from retention lagoons is frequently applied to soils over a relatively limited spatial area. Associated nutrients and bacteria can enter local streams via surface runoff, or can directly percolate into groundwater via the sandy soil matrix. Ultimately, these nutrients are transported to Fort Cobb Reservoir. Thus, the quality of reservoir waters for future human consumption is a major concern. Likewise, the U.S. Fish and Wildlife Service (USFWS) is concerned about impacts of animal waste on migratory birds in the area.

This report presents the results of a 2-yr study of the sources, fate, and effects of nutrients and bacteria in the Fort Cobb Reservoir and its watershed. The U.S. Bureau of Reclamation (USBOR) requested this study to determine the current biological and chemical conditions of the reservoir to determine existing and future threats to the water quality of the system.

OBJECTIVES

There were four objectives for this study:

- 1) Determine sources of nutrients and other contaminants that may be entering the reservoir;
- 2) Determine the current quality of water resources within Fort Cobb Reservoir;
- 3) Determine the health concerns related to coliform bacteria and algal cyanotoxins; and
- 4) Provide these data to the U.S. Bureau of Reclamation and other Federal and State agencies for help in development of watershed protection plans for Fort Cobb Reservoir.

primary productivity is the continued respiratory demand, which depletes remaining oxygen and decreases pH due to cellular respiration. These conditions are further exacerbated during cloudy weather periods with low wind mixing. Such conditions likely combined to decrease even surface dissolved oxygen and pH at the dam in September 2001. However, overall, oxyclines (and associated low dissolved oxygen and pH) are not a major problem in the reservoir due to the large oxygen supply available at the surface as indicated by Table 6 and Figure 16. However, under cloudy, windless conditions during the summer there are occasional dissolved oxygen depletions due to hypereutrophic conditions that should be monitored in the future should conditions worsen.

The high degree of reservoir uniformity can be compared using depth-specific comparisons of turbidity in the reservoir (Figure 21). Although turbidity concentrations varied seasonally and horizontally, as indicated by the data provided in Table 6 and Figure 14, there was relatively little vertical variation in turbidity concentrations. For example, at Sites 0 and 3 there was relatively little variation in turbidity with depth (Figure 21). In some cases there was a sudden increase in turbidity measured at the bottom; however, this was likely due to accidental physical disturbance by the YSI instrument during deployment.

Reservoir water quality: Phytoplankton community dynamics

A total of 76 phytoplankton taxa were identified during the study (Table 8). The phytoplankton community was dominated by the cyanobacteria (Phylum Cyanophycota) at all reservoir sites (Figure 22). The remainder of the community was dominated by Bacillariophyta, Chlorophycota, Chrysophyta, Cryptophycophyta, Euglenophyta, and the Pyrrophyphyta, however, these phyla were of low proportion compared to the cyanobacteria (Figure 22). Primary cyanobacterial genera in order of occurrence were *Microsystis*, *Wolleea*, *Anabaena*, *Oscilliatoria*, *Merismopedia*, *Anabaenopsis*, and *Aphanizomenon spp.* (Figure 23). The species composition observed is consistent with that of hypereutrophic reservoirs (Wetzel 1983).

Total number of algal cells averaged 53,363 cells/mL when averaged across all dates (Table 6). Location ($p=0.0099$), season ($p<0.0001$), and the location x season interaction ($p=0.0110$) had significant effects on algal numbers (Table 7). Total algal numbers were higher during the growing season compared to the senescent season. During the growing season algal numbers were much higher in the upper end of the reservoir compared to the lower end, but

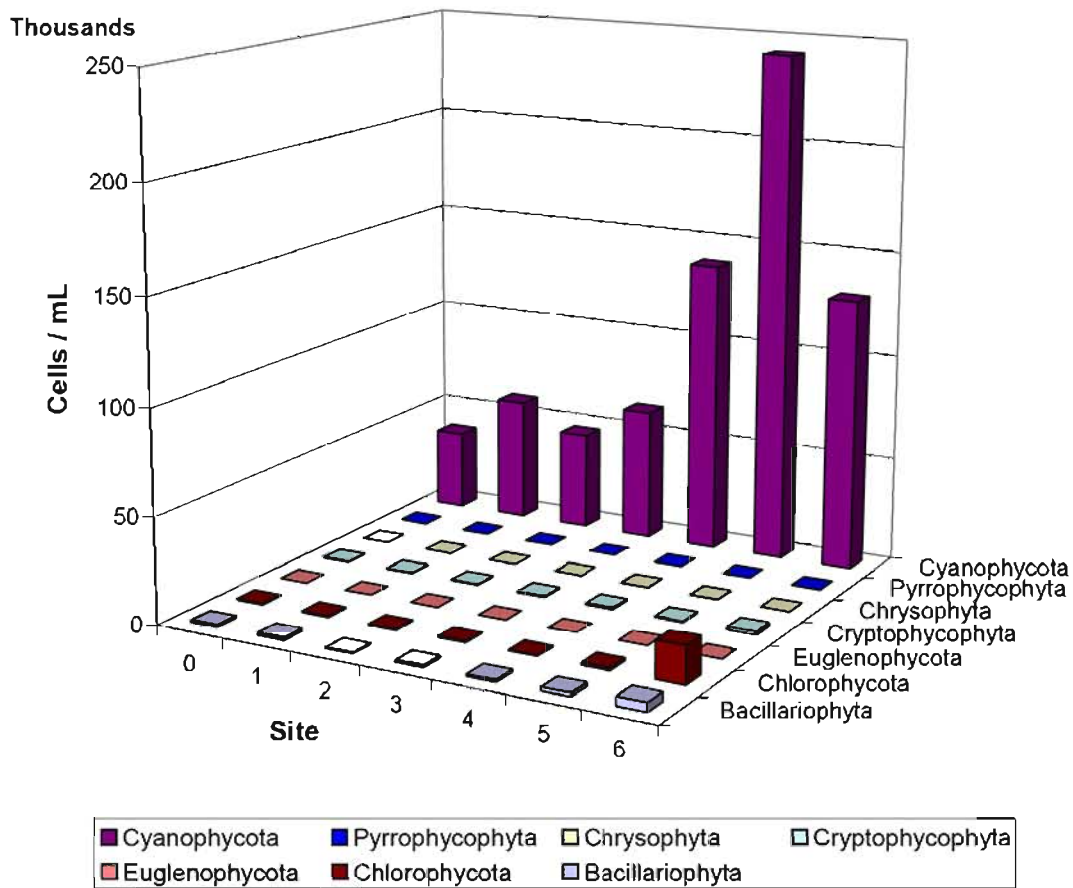


Figure 22. Spatial comparison of numbers of cells of major phyla of phytoplankton averaged over entire study (n=11 dates) at six sites in Fort Cobb Reservoir.